MISUSE OF CHILD RESTRAINT SYSTEMS IN CRASH SITUATIONS - DANGER AND POSSIBLE CONSEQUENCES.

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ABSTRACT :

Based on real-world crash data and recent field studies, an ad-hoc group was set up in order to have a better comprehension of the effects of misuse of Child Restraint Systems (CRS) on child protection. A testing programme of 60 single misuse situations was conducted. Test results confirmed that, in frontal impact, children have higher risk of being injured on a number of different body regions when CRS's are misused. This work provides material for educational and training purposes to help parents understand that child restraints need to be correctly fitted in order to provide the level of protection they are designed for.

INTRODUCTION

Within the E.U. project CHILD, real collision situations were analysed in depth and field studies were conducted in order to know the rate and the quality of use of restraint systems. In addition, a literature review was conducted [Le Claire et al, 2005]. In this document, it appears that a lot of children are not correctly restrained in most of the countries where studies are carried out, although the rate of misuse differs from one country to another one. French field study results [Tejera, 2006] show that 73% of CRS are not correctly used. This rate depends on the type of CRS (or the age of children) and the duration of the trip. It also shows that more than half of the misused systems show a combination of misuse on the same CRS. Other comparative studies from some partners [Hummel et al, 2004] highlighted that during the last 10 years, the number of times child restraint systems were misused is more or less stable, but that the rate of critical misuse is decreasing by approximately 50%.

Physical accident reconstructions performed in the CREST and CHILD projects have shown that the dynamic behaviour of a child dummy depends on the restraint conditions and in some tests with misuse, it was highlighted that misuse situations were critical in terms of loads on some body regions. The effectiveness of CRS decreases when misused but this statement was mainly based on expert point of view, and few scientific data are available on the subject. That is the reason why it appeared necessary to conduct a quantification of the decrease of protection due to misuse of CRS.

To make this possible, the Steering Committee of the CHILD project approved a research co-operative with partners from outside of the Consortium. This group is now composed of 23 partners from 7 European countries. It includes partners from the industry, from technical and medical universities and from national and private institutes, all involved in the child safety research area. Thus, the group has different perspectives of child safety but with the common aim: the comprehension and the reduction of misuse of CRS.

The work method of the group is based on the exchange of expertise, points of view and participation to the general knowledge, bringing real world data, providing material or performing tests. All data were gathered into a common base and a synthesis document addressing the effects of misuse produced, followed by a large dissemination of outcomes.

TEST SET UP

Based on real-world use and misuse observations, the group set up a testing programme based on the R44/03 sled test dynamic procedure using Q1, P1 ½ and Q3 dummies fitted with linear accelerometers in the head, the chest and the pelvis, 6 axis loads and moments sensors at the level of the upper neck and the lumbar spine. On the Q3, the chest deflection was measured, and two types of abdominal sensor prototypes developed in the CHILD project [Johannsen et al, 2006] were put on the child dummy. One has to bear in mind that the aim of these tests is not to evaluate CRS effectiveness; that's why they are tested in severity conditions corresponding to that of the current regulation. Each test was performed twice to check repeatability, and results were compared with the standard R44 installation (no misuse).

The use of a vehicle environment was necessary to be as close as possible to real-life conditions. Misuse of CRS/vehicle and child/CRS were tested but only in single misuse configurations (no combination).

The test matrix contains more than 80 misuse configurations and their comparison with the R44/03 standard installations. It includes all types of CRS with conventional or Isofix fixations. Among these, 48 misuse configurations have been tested to date. The list of test series performed is given in Appendix 1.

METHOD OF ANALYSIS

People in charge of testing presented results of each test series during plenary sessions; they were reviewed by the whole group. The analysis of each test was based on the observation of the child dummy and CRS kinematics, and dummy measurements. A chronologic list of events was set up. As no injury risk curve was available for Q dummies at this moment, only the comparison with the measurements from the reference tests was possible. The deviations of some parameters like the head and the chest acceleration resultants, neck forces and moments, and abdominal loads were particularly useful to base the final statement. In case of reproduction of an event (e.g. head impact), child dummies are often the best tool to use (duration of event, level of severity), but they are not sufficient indicators in case of "non event", which does not correspond necessarily to the absence of injury risk. For example, if there is an excessive dummy head excursion from the shell of the CRS during a test but that, due to the geometry of the vehicle environment, no impact occurs, the risk of head injury by impact on a rigid vehicle component is higher in that case than in the reference test, even if measurements from the child dummy show similar results. That is the reason why the analysis was not conducted only by the application of thresholds on the different body segments. It was necessary to complete it with an in depth analysis of the high speed films. These are, in configurations of non event, the most appropriate tool to be used to compare differences between the reference tests and misuse configurations. To evaluate the additional injury risk, the group made a conclusion case by case using a combination of measurements and films. The chronological analysis and the statements were reported in a document circulated to the partners [Lesire et al, 2006].

The analysis of results was conducted after a classification of misuse per type of CRS, and a focus was done on the following child body segments:

- head and face (H) using dummy data, such as head linear accelerations, HIC values and maximum 3ms acceleration resultant, but also high speed films, especially for non events recorded situations.
- neck and cervical spine (N) were paired with values from the dummy on the upper neck FX, FZ and MY. The analysis was linked with the one of the head in case of risk of head impact.
- chest (C) loads analysis was done with the linear accelerations and the 3ms acceleration resultant value, and to evaluate the chest compression, data from the deflection sensor were used on the Q3 dummy. The additional risk of the thoracic spine injury was not studied.
- abdomen and lumbar spine (A) , for which, forces and moments were used to determine lumbar spine injury risk, especially for misuse of booster cushions. The abdominal sensors values were compared to the ones of reference test if a penetration of a part of the restraint into this area was suspected, and they were combined with on-board camera high speed films.
- upper and lower limbs (L), for which statements are only based on the analysis of the films, as no sensor exists for this body segment on the Q dummies to date.

For each of these body segments, a risk factor has been given, from 0 to 3. A score of 0 means that neither films nor dummy measurements have shown an additional risk of severe injury. When a 1 is given, it means that, in the misuse situation, a slight effect has been observed but that the situation remains acceptable. If a body segment received a score of 2, it is because a clear influence of the misuse on the child dummy kinematics has been observed on the dummy measurements or on the films and that it means a higher risk of receiving injuries for a child in that situation. And finally, when the situation was critical, a score of 3 was given. In the presentation of results, a distinction has been made between bad installations of the CRS and bad restraint of children in a correctly fitted CRS, when results show a different repartition of additional injury risks across body segments. Sometimes, the conclusion was that the major risk was the ejection of the child from the CRS or the projection of the child and the CRS in the vehicle compartment, as shown in Figures 1 and 2. In that case, the head and neck were automatically given a score of 3 because of the high risk of severe head impact against a rigid part of the vehicle interior, possibly resulting in injuries such as skull fractures sometimes associated with cerebral or cervical spine damage. For the chest, because of the risk of high compression and for the limbs, because of the risk of projection onto rigid elements, which can be source of severe injuries, a score of 2 was reported.

Figures 1 and 2 : examples of situations with high risk of ejection

For each test or test series, results have been reported in a document which is one of the deliverables of the European CHILD project [Lesire et al, 2006]. A synthesis of this compilation of results is available in the Appendix 1 for each misuse situation.

ANALYSIS OF TEST RESULTS

It seems important to keep in mind that the effects of misuse depend on the CRS itself, the environment and the test conditions. For example, if, for a given misuse situation, conclusions are that no additional injury risk was detected, this doesn't mean that this situation is safe for a child with a size or a weight far from the one of the dummy used in the test, or for a design and material of the CRS which are not the same as in the test. When different CRS have been used in the same misuse configurations, only results of the one leading to worst case conditions are reported.

Of the 48 different misuse test configurations, 37 of them lead to a score of 2 or 3 for one or more of the body segments. This means that tested misuse represents a high or very high risk of sustaining severe injuries, and that most of them can be considered as major misuse in terms of impact on the child safety studies.

ANALYSIS PER BODY SEGMENTS:

(a) Head and face: they are the body segments for which the number of critical or high risk situations is the highest, with 30 cases for which danger has been stated. This result is valid for most of the CRS types, where head and face are the first body region in terms of additional injury risk. Films show that the risk of head impact, mainly because a higher head displacement in misuse configurations, is the first cause of additional injuries, such as skull or facial bones fractures, sometimes associated with severe brain injuries. In some cases, where impacts were produced, data from child dummies like 3ms acceleration and HIC values confirmed this statement.

(b) Neck and cervical spine: this situation is also critical because cervical spine injury outcomes often lead to permanent disability. These injuries can be sometimes associated with head impacts, so in many misuse configurations the risk of sustaining cervical spine damage is increased. The situation is even worse for young children due to the child late neck ossification and the relative big mass of the head, if loads are applied and create a relative movement between the head and the torso. It is a major risk when convertible CRS are used in a forward facing way instead of being installed rearward facing. Dummy measurements (My and/or Fz, Fx indicator) are there a good indicator. For children restrained by the adult seatbelt on booster cushions, the risk of additional cervical spine injuries is present if the seatbelt is positioned into the neck area before the test.

(c) Chest: the chest compliance to compression is relatively high for children when compared to adult. Because of this, the risk of rib fractures is relatively low, but the chest remains a body segment on which severe injuries can occur mainly by excessive compression: in misuse situations, the projection of the child onto a rigid part of the vehicle interior (front seatback for example) represents a high risk. The distribution of loads of the adult seatbelt for children seated on boosters can be different in normal and misused situations. It can become source of severe injuries as lung haematomas or clavicle, sternum and/or ribs fractures.

(d) Abdomen: the abdominal area is exposed to loads differently, according to the type of CRS considered. The main injury mechanism is the penetration of a part of the restraint system into the abdominal block. This is more likely produced when considering misuse configurations during which harness buckles or seatbelt straps become additional sources of injuries. Some misuse configurations have conducted to an extreme submarining kinematics for child dummies on booster cushions, leading to partial ejection of the dummy from its restraint system, even in pure frontal impacts. The situation could be even worse if this was combined with rotation.

(e) Limbs: the risk of limb fracture due to misuse situation is linked with two possible injury mechanisms. The most probable one is that, when the coupling of the dummy is less effective due to misuse, a higher displacement is allowed and the dummy kinematics is often limited by impact and loads of lower limbs. The second one is the projection of the child into the vehicle compartment, which can lead to fractures of lower and upper limbs.

ANALYSIS PER TYPE OF CRS:

(a) Rear Infant Carrier (RIC): 16 test series of such systems have been performed. Twelve show that the misuse situations represent a high additional risk of injury for a child. In the tested situations, head and neck are the body segments where the highest number of additional injuries have been seen, then comes the chest and finally the limbs. No additional risk on the abdomen due to misuse has been noticed in such restraint systems. The possible ejection of the child dummy or of the dummy and CRS has been observed in some cases with such systems and have a high influence on these results. A higher displacement of the child dummy or of the CRS and the dummy strengthens the possibility of an impact with the dashboard or with the front seatback structure. This represents a high risk of severe skull and brain injuries. Additional chest injury risk is essentially due to the possible ejection of the dummy or to the use of the system forward facing instead or rearward facing. In some cases, limbs can be injured during the rebound phase if not enough energy has been absorbed in the forward movement of the CRS.

(b) Forward facing seat with Harness: on 13 test series conducted, 10 have given results where a serious or a critical situation is shown. For these systems, when considering misuse about installation of the CRS in the vehicle, a higher displacement of the CRS and dummy has been observed in most of the cases. Head and limbs are then the most exposed body segments because of this additional risk of impacts in the vehicle interior. In some cases, the distribution of loads is different and sensors from the child dummies give higher figures in the area of the neck and of the chest for misuse situations. No influence on the abdomen was noticed in this kind of misuse tests. When considering misuse of restraining the child into a correctly installed CRS, the distribution is different. Head and chest are still the body regions for which the risk is the highest, but the abdominal sensors on the Q3 dummy show critical values when a part of the harness is intruding into this area. The neck tends to be less subject to additional injury risk, and no influence was seen for the limbs.

(c) Booster seats and booster cushions: it is important to notice that on the 13 misuse situations, 12 have led to a conclusion of danger for the child. Abdomen is for this type of restraint systems the first body segment; with 9 configurations where the additional injury risk is very high, due to seatbelt penetration. Most of these misuse situations led to a totally different kinematics of the dummy when compared to the one of the standard installation, and head impacts with rigid parts of vehicle interior (including floor) or with lower limbs are frequently possible. For chest and limbs a higher risk has been observed in approximately 50% of the cases.

(d) Other systems: the number of test series conducted on other systems does not allow many conclusions. Nevertheless, it is interesting to notice that rearward harness systems of group I (9-18kg) seem to be less sensitive to single misuse configurations in frontal impact, but, in the same time, as their installation requires additional fixation devices, they are possibly more subject to cumulated misuse.

ILLUSTRATION OF THE DANGER OF MISUSE THROUGH REAL-WORLD CASES AND THEIR REPRODUCTION IN TEST LABORATORIES

EXAMPLE 1: TWO VEHICLE COLLISION

The case vehicle was involved in a frontal collision into the side of the engine block of the target vehicle. An in depth investigation of accident was conducted in collaboration with the police force. The deformations of the structure of the front of the vehicles were measured and compared to the ones of crash tests that car manufacturers regularly perform. This method of comparison between crashed vehicles led to an estimation of the EES (Equivalent Energy Speed) of 65 kph for the vehicle in the accident. The overlap of the front of the vehicle was 40% of the left part. Detailed descriptions of injuries made by the medical doctor from the hospital were collected for all occupants involved in the crash. An in depth analysis of both vehicles was conducted in order to make a link between injuries and their probable sources. In the case vehicle, a 2-year-old female child was involved. She sustained frontal and parietal bones fracture (on the left side) and an extra-dural haematoma visible on CT scan, which is a critical brain injury. These skull fractures indicate that a head impact occurred during the accident, which was confirmed by the accident investigator, with the report of an impact against the rigid tablet on front seatback.

The CRS of the child involved in the collision was examined. The accident investigator clearly reported a misuse situation. The CRS, a convertible one, was used forward facing but was fixed to the vehicle using the points dedicated to the rearward facing installation. As a result, the base and the shell of the CRS were separated during the crash and some parts of the shell show some cracks.

This collision was reproduced in a crash test laboratory using a similar vehicle, a CRS of the same model and a P1 ½ dummy. The crash was performed against a deformable barrier with a collision speed of 70 kph, assuming that the barrier is absorbing the equivalent of approximately 5kph of energy. It seems that when comparing the structural deformations of the vehicle from the reconstruction with the ones of the vehicle from the accident, the energy of the original vehicle crash has been a little bit underestimated, and EES was closer to 70 kph. This variation of energy between the accident and the reconstruction does not seem to have a noticeable influence on the chronology of events shown by the child dummy kinematics. Some paint originally put on the head of the dummy shows two locations of head impact during the reconstruction test: on the left b-pillar at the height of the upper seatbelt anchorage and on the plastic tablet located on the left front seatback. The accident investigator reported a head impact with the tablet, but not the one with the B pillar because marks are difficult to be found in real-life crashes except if plastic parts are broken by the impact. The films allow the analysis of the kinematics of the child dummy. The CRS, due to the misuse situation, breaks after some milliseconds: the base and the shell are separated; the child and shell continue their way forward. The child dummy hits the B pillar with the left front part of his head and after a rotation of the head hits the rigid tablet. Impact locations are shown on Figure 3. The head impact on the left side of the skull on a rigid part of the car interior in the reconstruction test is satisfying and it lets us think that the injury mechanism was properly reproduced. Figure 4 shows the final position of the dummy.

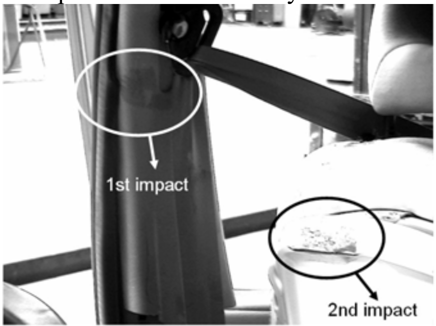

Figure 3: head impacts location Figure 4: final position - P1 ½.

Data measurements from the child dummy show high values for the head with 3 ms resultant acceleration value of 136g and a HIC36ms value of 3539. This corresponds to a very high risk to sustain an AIS3+

injury on the head [Palisson et al, 2007]. In the present case, it led to critical brain injuries and skull fractures, which could have resulted in permanent disability, but fortunately did not.

In this test, which has been conducted with a higher speed than in the previous sled test programme, it is confirmed that the misuse situations can lead to situations where, after damaging the CRS, the child is still restrained in the shell by the harness but she is free of restraint regarding the vehicle structure and the remaining energy has to be absorbed by impacting the vehicle interior.

EXAMPLE 2: PROSPECTIVE APPLICATION

In the following case, the aim is to understand the reasons for the fatality of a child involved in a frontal crash collision. A vehicle with a child was involved in a frontal crash into the side of another vehicle. Using the same method as in the first example, the EES for the case vehicle was estimated around 60 kph and the accident investigator reported an angle of collision of 260° and a direction of forces purely frontal for the case vehicle. Views of the vehicles on collision scene and of the CRS re-installed in the original vehicle are given in Figures 5 and 6.

Figure 5: view of the vehicles   Figure 6: CRS in the vehicle

The methodology used for the accident data collection is similar as the one used for the previous study. In this collision, two adults seated on the front seats and correctly using their seatbelts sustained minor injuries. Both frontal airbags deployed.

A 4-month-old male was restrained in a Rear Infant carrier (RIC) installed at the right rear position (no intrusion, no airbag deployment).

The child was not totally conscious on the accident scene, and was driven by his mother to the hospital. After 4 days, the child died from severe head injuries. Medical doctors from the hospital reported a contusion on the right side of the head, a subdural haematoma and a cerebral haemorrhage. In addition, an ecchymosis on the back of the of body the child, due to a high friction, was noted. Police forces, medical staff and parents did not understand the reason of a so high level of injury for a child that they considered as correctly restrained in a RIC.

At the examination of the child seat, the accident investigator found that the combination of misuse was certainly the main source of injuries: the position of the handle (visible on scene on pictures from the police) and the length of the harness straps (measured) allowed sufficient movement to the child to slip in the shell and have an impact with the handle which is on this CRS, made of metal. The level of brain injury can be then sufficiently high. It was interesting to try to evaluate how probable this scenario was, in a crash test laboratory.

Because the performance of a full scale test was far too much expensive (the opposite vehicle was a Ferrari) and because it does not allow comparison with other restraint configurations, a series of sled tests was performed in a body in white of Golf 4 using the frontal EuroNcap pulse of this vehicle and the adjustments of the vehicle components (e.g. front seat forward positions and seatback angles) to be as close as possible of the vehicle involved in the collision. Four tests were conducted, one with the RIC correctly positioned and with the correct harness length (R44 adjustment), one with the amount of slack measured on the original RIC and with the handle in wrong position, one with some slack but more reasonable and the handle in the wrong position and at least a repetition test of the most promising solution. The Q0 dummy was used for this test series because it was the closest dummy of the Q family to the size and weight of the 4-month-old child. It was instrumented at the level of the head, the chest and the pelvis with standard accelerometers and at the level of the neck with a 6 channel sensor. As result, the combination of misuse leads to the following situation: the dummy's shoulders escape from harness and the dummy ramps up and sustains a hard impact on the handle of the RIC after 80ms and a second impact with the front seatback at 95 ms. Figures 7 and 8 show the child dummy position before and after the test in what seems to be the most probable situation in real life.

Figures 7 and 8: position of the dummy before and after the test

Dummy measurements show a big difference between the reference test and the one reproducing the suspected combination of misuse. The HIC36ms measured in reference test was about 250 and the one in the misuse test nearly 650, which is 2.6 times higher even if not so high. The head resultant 3ms acceleration value goes up from 37g in the standard installation test to 71 g in the misuse configuration. For the neck, the biggest visible effect is on the forces applied in the Z direction. The minimum and maximum values on this parameter were - 58 N and 56 N in the reference test and - 1661 N and 1223 N in the misuse test. It is not possible here to compare the values to injury risk curves because the dummy size is not totally in line with the child's anthropometry which makes the location of the impact and its severity different from the real-life case. In addition, the severity of the EuroNcap test used in the test series is higher than the one of the original accident. Values of dummy loads are then certainly slightly different than the ones sustained by the child. Nevertheless, the dummy kinematics during the test allow a better comprehension of the one of the child in the real crash and it validates the statement from accident investigator: after this test series, it is very probable that the head impact was due to the combination of misuse, none was reproduced in the other tested configurations.

In addition, the accident occurred in winter and thick winter clothes can introduce slack that parents do not see. This can lead to dramatic situation especially because parents often put some slack for the comfort of the baby as they expect the baby to fall asleep. Such an example should be used to help in the choice of material used in process of design of a CRS, like a handle made of something else other than metal which should have led to different loadings.

In conclusion, such test series are good indicators for field investigators to update their knowledge and expertise, but also to illustrate that because a lot of parents are firstly taking care of the comfort of their children, they adjust CRS's in such a way that they are misused. Most of the people are not aware that this situation can lead to severe injuries or fatalities.

LIMITATION OF THE TEST SERIES

It is important to remind that results are only valid for the given test configuration (severity, CRS, vehicle environment) - but reflect general test conditions.

Accident reconstructions give good results but it is not an exact science; loads can differ from those sustained in the accident by children and a validation process of the data by experts is necessary. In addition, only relatively simple test configurations can be reproduced in test laboratories.

Sled testing is a good approach of understanding the kinematics and possible source of injuries, but if the pulse is not derived from the accident or the accident reconstruction, data from accident and test cannot be directly compared as exact crash loading conditions may have not been duplicated.

The size of the dummy may not exactly correspond to the size of the child, so measurements are not directly usable for injury risk determination, but it allows a comparison with other configurations.

CONCLUSIONS

Results from this ad-hoc group have scientifically confirmed that misuse are sources of additional risk of severe injuries for children. In some ways it has been possible to determine per CRS type and body segments what the main issues are.

It is important that results from this group are considered by CRS and car designers to improve the situation and, for that, the group has for main objectives to continue the dissemination of results at different levels: scientific community, vehicle and CRS developers, but also to the everyday road users through organisations and public debates. This should allow a rapid and consequent improvement of the level of safety for children, when transported in vehicles.

In addition, the ad-hoc group intends to continue to work on the item of misuse and the following steps are:

(a) A closer investigation of accident reconstructions performed in CREST and CHILD to have a better comprehension of the effects of misuse in real crash collision configurations.

(b) A sociological approach to child safety. The group would like to understand why parents are acting in this way, and for this to determine the level of knowledge of parents in the field of child safety, to define profiles of people misusing CRS through field studies, to investigate which parameters are determinant in the final choice of a CRS, and finally to understand what are the main sources of information used by parents to help them in their choice. A co-operation with an ad-hoc group of experts in sociology is under construction [Engel et al, 2006].

(c) The dissemination of the results based on two main actions: present results in conferences, and make available a selection of data – DVD - for training and education purposes.

(d) For frontal impact: to complete the test matrix, investigate the effects of combination of misuse, complete the work initiated on advanced safety devices interactions, and assess the effect of out of position (sleeping, relaxed,…).

(e) For side impact: Start a similar work on misuse effects.

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REFERENCES:

Le Claire, M., 2005, Literature review – not published – deliverable from CHILD project - www.childincarsafety.com

Tejera, G., Results of Spanish and French CRS misuse surveys, CHILD dissemination workshop, 2006. , www.childincarsafety.com

Hummel, T., Finkbeiner, F., Roselt, T. – A study of the use of CRS and the potential improvement which may be achieved with ISOFIX, GDV report , 2004

Lesire, P., Alonzo, F., Cuny, S., CHILD project deliverable: D13b – Report of testing programme of misuse, 2006, status: public

Johannssen, H., et al. Abdominal injuries, injury criteria, and abdominal sensors for child dummies of the Q family, Ircobi 2006

Palisson, A. et al , Estimating Q3 dummy injury criteria for frontal impacts using the CHILD project results and scaling reference values, Ircobi 2007

Engel, R., et al. Social demand in terms of child safety, International Conference on protection of children in cars, Munich 2006

APPENDIX 1: list of misuse situations that have been compared to standard installations and risk score for different body regions.

Symbols used in the table: **H** – Head and face, **N** – neck and cervical spine, - **C** – chest , **A** abdominal area, **L** – Limbs (upper and lower)

Rearward Infant Carrier: (RIC) Group 0+ (0 – 13kg)	**H**	**N**	**C**	**A**	**L**
CRS attachment : wrong route of seatbelt					
Both parts of seatbelt through lap belt route	3	2	2	0	2
Only diagonal belt is used	3	2	2	0	2
Inversion of diagonal/lap strap	3	2	2	0	2
Diagonal strap out of rear guide	3	2	2	0	2
Fixation of Isofix base and CRS with seatbelt	1	1	1	0	0
CRS attachment : wrong CRS inclination					
Lying position	2	1	0	0	0
Between normal and lying position	0	0	0	0	0
Upright position (too short seatbelt length)	0	0	1	0	0
CRS attachment : Isofix misuses					
2pt Isofix with support leg incorrectly used	2	2	2	0	0
Only one fixation of Isofix base clicked	3	3	2	0	2
Wrong fixation on Isofix base – front anchorage	0	0	0	0	0
Wrong fixation on Isofix base – rear anchorage	2	2	1	0	0
CRS installed forward facing on the Isofix base	3	3	2	1	0
CRS attachment : others					
CRS installed forward facing instead of rearward	3	3	2	1	2
Dummy attachment					
Harness under the arms	3	3	2	1	2
Wrong harness height adjustment - lower slot	3	3	2	1	2
Forward facing CRS Harness Group 1 - (9-18kg)	**H**	**N**	**C**	**A**	**L**
CRS attachment					
CRS restrained by the fixing points dedicated to rearward facing attachment	3	3	2	1	3

CRS only restrained by its base	3	3	3	1	3
CRS installed without using lockers	1	0	0	0	1
CRS installed using lockers on both side	0	0	0	0	0
Slack in seatbelt diagonal part – 4 fingers	2	0	0	0	2
Slack in seatbelt lap belt part – 4 fingers	2	0	0	0	2
Basis of CRS not stable declining to door panel	2	0	0	0	2
Basis of CRS not stable declining to centre	2	0	0	0	2
Dummy attachment					
Harness twisted - 2 turns on each strap	0	0	2	0	0
5 pt harness transformed in 3 pt harness	2	2	0	3	0
Harness under the arms	3	2	2	3	1
Wrong adjustment of harness shoulder height					
maxi low for older dummy	0	0	1	0	0
maxi high for smaller dummy	2	1	2	2	0
Rearward facing CRS Harness Group 1 - (9-18kg)	**H**	**N**	**C**	**A**	**L**
2 pt Isofix + force leg - without additional straps	1	0	0	0	0
Fixation but without additional fixation devices	2	1	2	0	0
CRS installed with no slack at all	0	0	0	0	0
CRS installed with 4 fingers slack on each strap	0	0	0	0	0
Forward facing CRS with shield Group 1 - (9-18kg)	**H**	**N**	**C**	**A**	**L**
Gap between child and shield space + 3 fingers	3	2	2	3	3
Diagonal part of seatbelt on the chest of the child	1	1	2	0	0
Booster cushion Group 2 (15 – 25 kg)	**H**	**N**	**C**	**A**	**L**
Seatbelt above internal horn	1	1	1	3	1
Seatbelt above external horn	1	1	1	3	1
Seatbelt above internal and external horn	2	1	1	3	1
Upper seatbelt router device is not used	1	2	0	0	0
Diagonal part of seatbelt behind dummy's back	3	1	0	3	1
Diagonal part under the arm of the dummy	3	1	0	3	1
Wrong adjustment of seatbelt router – maxi low	0	0	0	0	0
Wrong adjustment of seatbelt router – maxi high	1	2	2	0	0
Slack in diagonal section of seatbelt – 3 fingers	2	1	2	2	2
Slack in diagonal section of seatbelt – 5 fingers	3	1	3	2	2
Slack in lap section of seatbelt - 3 fingers	2	1	2	2	2
Slack in lap section of seatbelt - 5 fingers	3	1	2	2	2
Seatbelt twisted – 2 turns	0	0	2	1	0